CHEMICALS

Project Fact Sheet

Production of Phenol Formaldehyde Resins from Recycled Composite Materials

Benefits

- Reduces energy and oil consumption
- Saves valuable resources
- Removes a rapidly growing waste stream from landfills
- Reduces the cost of milled or chopped carbon fiber

Applications

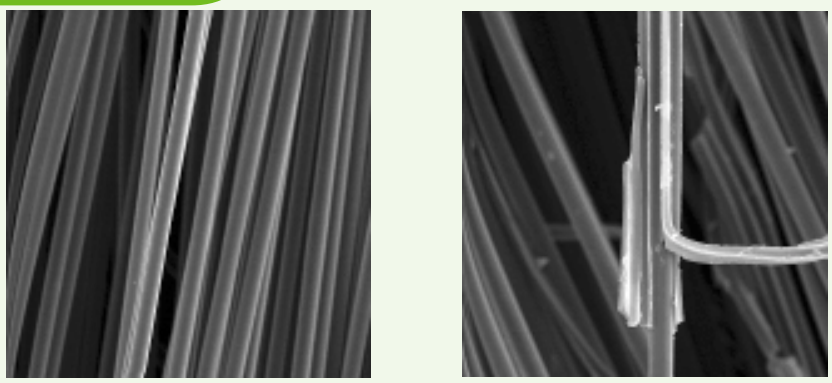
Technology to create phenol formaldehyde resins from recycled composites will be valuable to large-scale industrial composite users such as the transportation, aerospace, chemical processing, medical, and sporting goods sectors, as well as the U.S. military and NASA. The phenolic resins can be used in the forest products industry to fabricate plywood, chipboard, and particleboard.

Conversion of Liquid Hydrocarbon to Phenol Resins Closes the Loop on Carbon Fiber Recycling

Carbon fiber reinforced-composite materials are moving into high-volume applications such as transportation and construction, subsequently creating a new waste stream. Recycling of thermoset composites can recover high-quality and high-value carbon fibers from this waste stream. However, current wet chemical recycling processes produce a liquid hydrocarbon byproduct during the breakdown of the matrix resin (usually epoxy) that has limited direct value. The amount of liquid byproduct is not sufficient to justify building a conventional refinery to recover the individual byproduct components, meaning the only options for dealing with the byproduct are disposal of the potentially hazardous waste or use as a low-value energy source. To close the composite recycling loop, project partners are extracting the phenolic components of the liquid hydrocarbon byproduct stream to produce high-value phenol formaldehyde (PF) resins.

Project partners have shown that phenolic starting material can be generated from various hydrocarbon samples to produce a superior phenolic resin product at minimal cost, requiring neither high operating expenses or large capital investment. PF resin is an ideal target for the hydrocarbon byproduct stream since PF resins do not require the same high level of purity as other common polymers. The vast majority of PF resins are used for wood composite applications, such as wood panels. The resins produced by project partners will be lower cost and more consistent in composition than those derived from currently available sources.

Carbon Fiber Recycling



SEM Micrograph photos showing reclaimed carbon fibers (left) and the recycling reaction as it strips away resin from the fibers (right).

Project Description

Goal: The goal of this project is to develop high-quality phenol formaldehyde (PF) resins from the hydrocarbons produced during recycling of carbon fiber-reinforced thermoset composites. Research will demonstrate that valuable carbon fiber can be successfully reclaimed from composites and every part of the byproduct stream can be reused to generate value. This holistic approach to recycling an entire unused waste stream is economically and environmentally sound, and will open enormous business opportunities in the future.

Progress and Milestones

Early-stage research successfully demonstrated the technical viability of the new technology. The primary goal of initial research was to determine the feasibility of producing high-quality phenolic resins from the phenol-based hydrocarbon compounds produced in the recycling process. Characterization of the carbon fibers reclaimed by the recycling process and evaluation of the overall economics of the process were secondary goals. Results showed that phenolic resin could be prepared from all hydrocarbon samples produced by the recycling process. Some of the phenolic resins prepared with phenols from the recycled composites had superior mechanical properties compared to an industry standard control resin. Reclaimed carbon fibers also showed near-virgin properties, and the process economics were very favorable.

Current research emphasizes the development of phenolic resin production into a mature technical process and investigates uses for any parts of the hydrocarbon stream that cannot be integrated into the resin. Additional uses for the reclaimed fiber will also be investigated, and researchers will conduct an overall economic assessment of the recycling process. Specific tasks include:

- Produce large quantities of hydrocarbon byproduct
- Set up pilot extraction/distillation plant
- Analyze hydrocarbon product and evaluate variability
- Produce and test phenolic resin
- Evaluate resin for toxicity and outgassing
- Evaluate non-phenolic conversion and use
- Develop new markets for reclaimed fiber
- Develop a pilot-plant layout and process specification

Commercialization

Adherent Technologies, Inc. will market the developed technology to the five main worldwide resin producers. The resin from the developed recycling process has shown superior properties over standard resins and should be easily marketable as an additive to standard resins to reduce cost. Georgia-Pacific Corporation has expressed interest in evaluating the phenolics from the recycling process and will conduct tests in support of the current research program.

Project Partners

Adherent Technologies, Inc.
Albuquerque, NM

Air Force Reseach Lab
Albuquerque, NM

Cytec
West Patterson, NJ

Desert Analytics
Tucson, AZ

Georgia Pacific Resins
Decatur, GA

Los Alamos National Lab
Los Alamos, NM

National Renewable Energy Lab
Golden, CO

New Mexico Engineering Research Institute
Albuquerque, NM

Oak Ridge National Lab
Oak Ridge, TN

Sandia National Lab
Albuquerque, NM

University of New Mexico
Albuquerque, NM

For additional OIT program information, please contact:

Charles Russomanno
Office of Industrial Technologies
Phone: (202) 586-7543
Fax: (202) 586-1658
charles.russomanno@ee.doe.gov

Visit our home page at
www.oit.doe.gov/chemicals

For information on the SBIR program, please contact:

Robert E. Berger
SBIR/STTR Program
Phone: (301) 903-1414
Fax: (301) 903-5488
sbir-sttr@science.doe.gov

Visit the SBIR home page at
http://sbir.er.doe.gov/sbir

Office of Industrial Technologies
Energy Efficiency
and Renewable Energy
U.S. Department of Energy
Washington, D.C. 20585

OIT

September 2001